EVALUATION OF SCLERODERRIS CANKER

IN RED PINE PLANTATIONS OF THE LAKE STATES

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ABSTRACT

From 1966 to 1970, plots established in 31 red pine plantations were examined annually to evaluate damage caused by *Scleroderris lagerbergii* Gremmen. During this period, the percent of trees infected increased from 12 to 30 percent; mortality caused by Scleroderris canker from 5 to 10 percent. Disease-caused mortality was severe (15-32%) in only a few of the plantations, but the rapid increase in infection indicates the disease may seriously hamper reforestation efforts in the future. Recommendations are included.

INTRODUCTION

IN THE SPRING of 1951, foresters noticed extensive damage in some of the young red pine plantations on the Ottawa National Forest in Upper Michigan. Tree mortality was common, and the lower branches of most of the surviving trees were dead. Many trees had cankers on the main stem or branches. The damage was particularly severe in the small topographic depressions called frost pockets *(Schneider 1961)*. The characteristics of this "X-disease" became familiar in the 1950's, as many other red pine plantations throughout Upper Michigan were found to have trees exhibiting the same symptoms. Eventually, a research project to ascertain the cause was established, and in 1964 John Ohman, of the North Central Forest Experiment Station, isolated a fungus from both red and jack pine stem cankers. The fungus was identified as *Scleroderris lagerbergii* Gremmen. Two years previously Erick Jorgensen of the University of Toronto had isolated the same fungus from infected red pine seedlings in Ontario *(Ohman 1966)*.

The disease caused by this fungus, Scleroderris canker, has caused injury to conifer plantations and nurseries in Europe for nearly a century (Brunchorst described the disease in 1888). Severe epidemics have occurred in western Europe, notably Scandinavia, when environmental conditions favored infection and disease development *(Björkman 1963)*. Similar outbreaks have occurred in England *(Read 1966)*. In North America, Scleroderris canker has been found in northern Michigan, Wisconsin, Minnesota and New York and in Ontario and Quebec.

A 1965 survey of 4 to 10 year old red pine plantations on the Ottawa, Hiawatha, Nicolet and Chequamegon National Forests revealed that two-thirds of the 176 plantations examined were infected *(Skilling and Cordell 1966)*. Estimated losses, including "missing" trees (empty planting spaces), exceeded 40 percent of the original stocking. At the time it could not be determined what portion of the losses could be ascribed to Scleroderris canker or what additional losses could be expected. Nor was it known how quickly presently uninfected trees in these plantations would become infected.

In 1966 permanent plots were established in 31 of the infected plantations to determine the rate of spread of infection and tree mortality caused by the disease. The plots were examined each summer from 1966 to 1970. The results of this study are presented here.

METHODS

Only red pine plantations found infected in 965 and in which at least half the trees had urvived were considered suitable for the 1966 tudy. The plantations were divided into two ge groups—7 to 10 years old and 4 to 6 ears old. The two age groups are herein eferred to as the "older group" (planted pring 1957 to spring 1960) or "younger roup" (planted spring 1961 to fall 1962).[1] hree or four (the intended number) planta- ions from each age group were selected for ach of the four Forests (figure 1).

Five square, 1/20th acre permanent plots vere established in each plantation, except or three plantations on the Ottawa National orest. In these three, only four plots per lantation could be established. All plots were paced at least three chains apart and at least wo and a half chains from the plantation dge. They were systematically arranged in an attempt to obtain a representative sample of each plantation, but no plots were placed where pine mortality had exceeded 50 percent. Each plot was marked with corner stakes, and maps were prepared to show the location of the plot and of each tree within it.

Annually each tree was examined and classified as to condition (healthy, poor vigor, dying, or dead) and to disease symptom expression (dead terminals, dead branches, stem cankers, and a yellow-green discoloration of the wood beneath the bark of dead tree parts). Herein, an "infected" tree is a damaged tree having this characteristic discoloration of the wood. Cankered or otherwise damaged trees without the discoloration were not considered infected. Ohman *(1966)* and Skilling and Cordell *(1966)* found the discoloration highly reliable as a diagnostic symptom. Therefore, laboratory culturing was not necessary for this study.

Infected trees that died were retained in the records among the "infected" even if the trees eventually disappeared. However, live trees from which infection was removed—as when the infected branch was broken off by snow—were considered uninfected the year the discoloration could no longer be found.

[1]Research completed since the plan was written *(Skilling 1969)* indicates the spring '60 planting was exposed to inoculum in nursery at the same time as the fall '59 plantings. Therefore, two plantations that were included in the younger group (spring '60 plantings) in interim reports were changed to the older group. The change alters the overall results only slightly (1% or less).

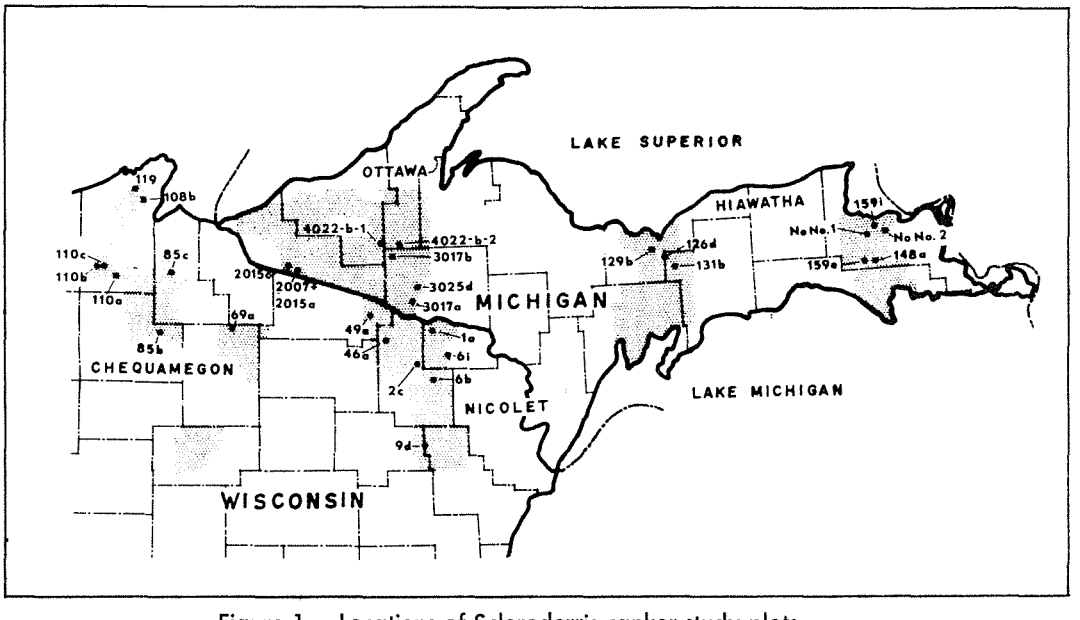


Figure 1.—Locations of Scleroderris canker study plots.

RESULTS AND DISCUSSION

Spread of infection and mortality data for all the plots are summarized in table 1. Information by Forest is presented in the appendix (tables 4-7).

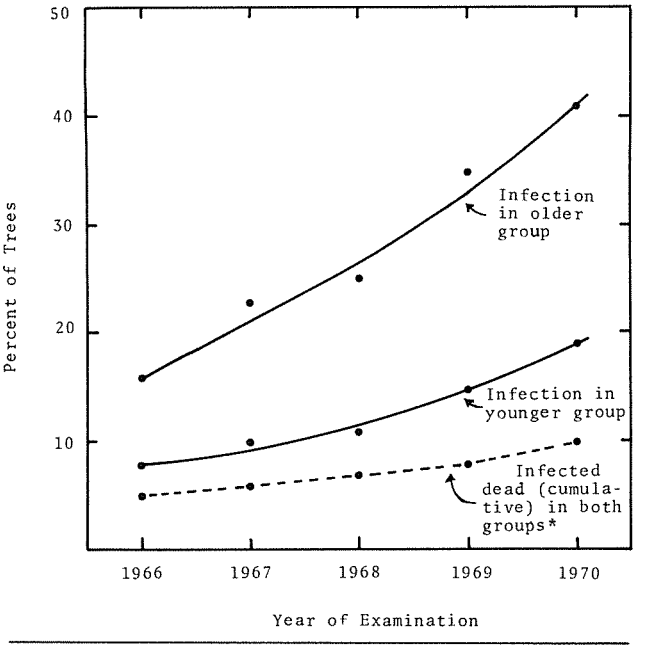
As shown in figure 2, as well as in table 1, infection increases at a more rapid rate as the stands grow older. In the older group the percent of trees infected rose from 16 to 41, or an average of 6 percent per year. In the younger group infection rose from 7 to 19 percent, or 3 percent per year. Specifically, the annual increases in percent of trees infected are:[2]

	Older Group	*Younger Group*
1966-67	6	2
1967-68	2	1
1968-69	10	4
1969-70	7	5

The trend—an increase in infection rate with time—is not surprising, since the within-stand inoculum load would be expected to build up with time. In contrast, the mortality rate has been steady for both groups—about 1 percent per year from 1966 to 1969; 2 percent in 1970.

Except in a few cases, such as that of plantation 108b on the Chequamegon National Forest (table 4), healthy older trees six feet or so tall are able to survive attacks by the fungus and only the low branches are killed. Therefore, the tree mortality rate does not correlate with the infection rate. The data in table 2 shows that losses of 4-10 year old "healthy" trees (i.e. trees growing reasonably well and unblemished by dead branches or other symptomatic injuries) averaged less than 2 percent. Even on the Hiawatha, where losses were most severe, averaging 4.6 percent (table 3), the maximum loss of "healthy" trees within the plots of any one plantation was 12 percent. Generally then, if a tree has not been infected by the fourth year after planting, the chances are slight that an attack

Figure 2.—Comparison of average infection of older and younger age groups and mortality of both groups by year on Scleroderris study plots.



*The differences between the 2 age groups are less than 1%.

[2]Statistically, the differences are significant at the 95% level in 66-67, not significant in 67-68, significant at the 80% level in 68-69 and not significant in 69-70. Apparently, the infection rate in younger group gradually approaches that of the older as the number of targets available declines.

Table 1.—*Infection and tree mortality on Scleroderris canker study plots, 1966-1970*

Group	Tree	Percent of trees infected		Percent of trees dead (Cumulative)			
				all dead		infected dead	
		1966	1970	1966	1970	1966	1970
Older	3,996	16	41	8	16	5	10
Younger	4,071	7	19	11	19	5	10
Both	8,067	12	30	10	17	5	10

Table 2.—*Infection and death by 1970 of trees on the Scleroderris canker study plots classified "healthy" in 1966, by age group*

Group	Number of trees "healthy" in 1966	Percent infected and killed by 1970[1]		
		Mean[2]	Confidence limits[3]	
			Upper	Lower
Older	1,828	1.0	2.2	0.2
Younger	3,521	1.5	3.7	.3

[1]Data subjected to arcsin transformations to correct for skewed distributions.

[2]Mean of percents by plantation.

[3]95% confidence level.

Table 3.—*Infection and death by 1970 of trees on the Scleroderris canker study plots classified "healthy" in 1966, by Forest*

Forest	Number of trees "healthy" in 1966	Percent infected and killed by 1970[1]		
		Mean[2]	Confidence limits[3]	
			Upper	Lower
Chequamegon	1,189	1.2	4.7	<0.1
Nicolet	1,619	.1	.5	.0
Ottawa	1,065	.6	1.8	< .1
Hiawatha	1,475	4.6	8.5	1.8

[1]Data subjected to arcsin transformations to correct for skewed distributions.

[2]Mean of percents by plantation.

[3]95% confidence level.

vill be lethal. These data confirm observations f others *(Dorworth 1970)* that Scleroderris anker is a threat primarily to very young ed pine.

In most of the older plantations mortality ccurred among trees of low vigor, debilitated y the disease or, sometimes, by other factors. hat is, many Scleroderris-infected trees die lowly, sometimes lingering on for years. This rolonged die-off offsets the expected decline n the mortality rate of older trees and is the rimary reason that the Scleroderris canker-aused mortality rates are about the same for oth age groups (table 1 and figure 2).

Infection rates are highly variable between lantations (tables 4-7). Some variation in lantation infection may be due to differences n the amount of infection originally in the lanting stock. However, topography is probbly more important. Plantation 108b, for xample, is in a "classic" frost pocket. It is ocated within and surrounding the edges of a depression. Hardwood trees around the depression deepen it, in a meteorological sense, even further (front cover photo). In the lowest areas, all trees were killed, most of them rather suddenly in 1967 and 1968. The trees had grown well in the years before mortality occurred.

Severe losses also occurred on other, reasonably level sites, such as that of plantation 126d on the Hiawatha, which sustained 32 percent mortality (table 7). Studies have shown open fields may have meteorological conditions similar to those of frost pockets *(Skilling 1968)*, and perhaps this explains why equally severe damage occurred. Plantations on sites subject to conditions that cause low, sprawled trees (e.g. flattening due to heavy snow) may be highly infected and seriously damaged. Plantation 119 on the Chequamegon National Forest occupies such a site and losses have reached 35 percent—at least half due to Scleroderris canker. Hazard-

ous sites of these types may be difficult to recognize prior to planting.

As previously stated, red pine 6-8 feet in height are relatively safe from lethal attacks, though the lower branches may be infected and killed. In plantation 129b on the Hiawatha, for example, the trees are growing very well even though nearly all are infected (back cover photo). However, the inoculum is now pervasive in this plantation and any new seedling, volunteer or planted, that appears within or close to the stand is almost certain to be infected and killed within a few years. With time, the amount of inoculum may decrease—when all lower branches are dead—but indications are the fungus will not die out of a plantation where it has become well established. It is usually perpetuated on surrounding or intermixed volunteer trees, normally jack pine *(Dorworth 1970)*.

SUMMARY AND CONCLUSIONS

Of the 8,067 trees included in this study, Scleroderris canker has caused, at most, a loss of ten percent (table 1). Of course, some trees were lost before the study began—about 19 percent of the planting spaces were empty in 1966—and there is no sure way to determine what happened to them. Possibly more nursery infection occurred prior to 1966 than after, but experience with seedlings used in other studies carried out from 1966 to 1969 suggests that less than one sixth of the "missing" were killed by the disease. This would make a total loss of, at most, 13 percent due to Scleroderris canker.

However, as with most averages, the summary figures conceal about as much as they reveal. The infection in plantation 2c on the Nicolet is of little consequence, while in plantation 126d on the Hiawatha the fungus killed at least a third of the trees. Therefore, while the average figures may be useful in determining overall priorities—for example, for allocation of research funds—the land manager must judge the seriousness of Scleroderris canker on a plantation to plantation basis. Unfortunately, other than such admonishments as "avoid frost pockets", we are not now able to advise the forest manager where to plant in order to avoid severe damage. Rather than seeking those situations which result in "acceptable" losses, the forest manager would find it simpler and more effective to avoid getting Scleroderris canker into the plantation when the trees are planted.

While the average mortality rate of these older trees does not seem cause for great alarm, the average rate of spread is anything but comforting. Disease incidence more than doubled between 1966 and 1970. Possibly there is already sufficient inoculum in the field to allow the disease to become, within 50 years, as prevalent in the northern conifer region as the blister rust of white pine. Such a development could make it difficult to regenerate red or jack pine, particularly in areas in which trees are subjected to severe environmental stress. By preventive measures the eventuality implied by the data can at least be delayed. The planting of infected stock should be stopped, even if this involves considerable expense.

RECOMMENDATIONS[3]

Forest Management

1. Trees should not be planted in the bowl-shaped depressions called frost pockets.
2. Heavily infected stands should not be "filled" with replacement seedlings, nor should new plantations be established close to infected stands (within a half mile until research can provide something other than a guess).
3. The damage suffered by several plantations of the Hiawatha National Forest suggests that Scleroderris canker should be considered a major limitation to reforestation of red pine on the Forest.

Nursery Management

1. Great effort should be devoted to the production of completely uninfected stock.
2. Shipments of red pine from nurseries where the disease has been found should

[3]Recommendations are based on general knowledge of the disease, rather than solely on the findings presented here.

be delayed as long as possible to allow time for symptom development. Infected seedlings can often be detected, and culled out of the beds (and burned or buried).

3. Shipments of forest planting stock from one nursery to another for transplanting should be forbidden. Even exchanges of stock for distribution purposes only should be discouraged. No individual planting program is urgent enough to justify the risk of contaminating nurseries with dangerous pathogens.

Research or Pest Management

1. A more practical chemical for control of the disease in nurseries is needed. The fungicide Daconil®[4] shows promise, but testing is not complete.
2. The possibility of destroying seriously damaged plantations by burning, and then replanting them, should be tested.
3. The distance from an infected plantation that a new plantation can be safely established should be determined.

[4]Mention of a particular product does not imply endorsement by the U.S. Department of Agriculture or the Forest Service.

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APPENDIX

ole 4.—*Infection and tree mortality on Scleroderris canker study plots, 1966-1970, Chequamegon National Forest*

rict	Plantation	Season & year planted	Trees present in 1966	Percent of trees infected		Percent of trees dead (Cumulative)			
						All dead		Infected dead	
				1966	1970	1966	1970	1966	1970
burn	108b	F-58	324	32	98	5	22	4	21
	110a	F-59	249	10	11	7	9	6	8
	110b	F-59	186	12	13	7	8	4	5
	110c	F-59	201	15	52	7	10	6	9
)lder Group Totals			960	19	49	6	13	5	12
Falls	69a	F-61	257	7	8	9	13	5	7
en	85b	F-61	141	6	12	9	13	6	7
	85c	F-61	196	11	17	15	17	9	10
burn	119	F-62	253	10	26	19	35	9	18
ounger Group Totals			847	9	16	13	20	7	11
Forest Totals			1,807	14	34	10	17	6	12

Table 5.—*Infection and tree mortality on Scleroderris canker study plots, 1966-1970, Nicolet National Forest*

rict	Plantation	Season & year planted	Trees present in 1966	Percent of trees infected		Percent of trees dead (Cumulative)			
						All dead		Infected dead	
				1966	1970	1966	1970	1966	1970
nce	1a	S-58	310	2	9	2	4	1	1
	2c	S-59	385	1	1	1	2	1	1
Lakes	46a	S-60	312	6	9	9	24	3	7
River	49a	S-60	337	21	52	14	26	8	17
)lder Group Totals			1,334	8	18	6	14	3	6
a	6b	F-61	192	5	6	10	17	4	5
nce	6i	S-62	341	4	9	8	13	2	4
wood	9d	S-62	301	<1	1	3	4	<1	1
ounger Group Totals			834	3	5	7	11	2	3
Forest Totals			2,179	6	13	6	12	3	5

Table 6.—*Infection and tree mortality on Scleroderris canker study plots, 1966-1970, Ottawa National Forest*

ict	Plantation	Season & year planted	Trees present in 1966	Percent of trees infected		Percent of trees dead (Cumulative)			
						All dead		Infected dead	
				1966	1970	1966	1970	1966	1970
tiver	3017a	S-58	146	9	24	8	18	4	7
	3017b	S-58	209	13	37	10	15	7	10
ner	2007	S-59	196	17	42	8	13	5	6
der Group Totals			551	13	35	8	15	8	8
ner	2015a	S-62	221	8	14	14	18	5	8
	2015c	S-62	215	9	17	13	24	8	12
tiver	3025d	S-62	198	7	7	11	17	5	7
n	4022b-1	S-62	330	21	27	12	20	8	16
	4022b-2	S-62	295	5	25	7	15	2	5
ounger Group Totals			1,259	11	19	11	19	6	10
Forest Totals			1,810	11	24	10	18	6	9

able 7.—*Infection and tree mortality on Scleroderris canker study plots, 1966-1970, Hiawatha National Forest*

rict	Plantation	Season & year planted	Trees present in 1966	Percent of trees infected		Percent of trees dead (Cumulative)			
						All dead		Infected dead	
				1966	1970	1966	1970	1966	1970
ing	126d	S-57	262	45	81	25	43	17	32
	129b	F-58	306	32	95	5	9	4	8
	48a	F-58	314	12	38	9	15	4	8
ing	131b	F-59	259	13	40	10	17	4	9
lder Group Totals			1,141	25	64	12	20	7	14
	No No. 2	S-61	298	8	25	25	42	5	15
	No No. 1	F-61	229	5	40	6	20	2	14
	159e	S-62	321	4	14	9	12	2	5
	159i	S-62	283	8	46	8	24	5	19
ounger Group Totals			1,131	6	30	12	24	3	13
Forest Totals			2,272	16	47	12	22	5	13